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Financial Management Performance Evaluation of Universities Based on Comprehensive Weighting K-Means Algorithm

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Abstract. To accurately and quantitatively reflect the financial management ability of colleges and universities, a financial management performance evaluation method based on comprehensive weighting k-means algorithm is proposed. Based on the analysis of related concepts, theories and evaluation methods, the performance evaluation index system of financial management in colleges and universities is established. The subjective weight of each attribute is determined by analytic hierarchy process, and the objective weight of each attribute is determined. Then we use the K-means method to calculate the weight of each attribute. The judgment matrix is obtained to test and correct previous results, and the final evaluation level can be acquired. In the case analysis, the actual financial index data of a university is standardized to test the adaptability of the index system to the financial management performance evaluation of higher vocational colleges. The evaluation results show that the clustering accuracy of this algorithm is high, and it can objectively acquire the comprehensive evaluation of the overall budget performance of university financial management, to improve the efficiency of resource use and output benefits of universities.

Keywords. performance evaluation; AHP; K-means; CRTIC; financial management; index system

1. Introduction

In the process of large-scale, comprehensive and market-oriented colleges and universities, in the case of insufficient government funding and the widening gap between supply and demand of funds, colleges and universities increasingly rely on loans from financial institutions, which to a considerable extent increases the risk of subsequent financial operations. Therefore, we need to fully understand the financial status of colleges and universities, evaluate the financial operation results, find out its shortcomings and correct them, so that the funds can be fully used, which is the main purpose of financial performance evaluation of colleges and universities [1]. Due to the fuzziness of the output assessment of colleges and universities and the difficulty of measuring the quality of talents, it can only be assessed by some indicators that can quantitatively reflect the work achievements of colleges and universities. The author believes that the financial indicators of colleges and universities are highly

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comprehensive, and the performance of school management will ultimately be reflected in the financial indicators. Therefore, the financial performance evaluation of colleges and universities refers to the selection of specific evaluation indicators, the use of scientific evaluation models, the use of scientific evaluation methods, the use of the information provided by the current financial management and accounting system of colleges and universities and other relevant materials, the scientific, objective and fair measurement, comparison and comprehensive evaluation of the process and results of the operation behavior of colleges and universities, and finally the comparison of the evaluation results A financial statistical analysis method of ranking and analysis [2].

Based on the analysis of relevant concepts, theoretical basis and evaluation methods, this paper makes an in-depth study on the performance methods of financial management in Colleges and universities. Firstly, the connotation of financial performance is explained, the AHP and K-means method are introduced, and the general process is summarized and analyzed. Then combined with demand analysis, social research, expert evaluation and other comprehensive factors, the index system of university financial management performance is established. By integrating the subjective weight of AHP and the objective weight of critical, the use of highly objective k-means algorithm for correction is adopted to improve the accuracy of performance evaluation calculations, and obtain the final index weight value. The results of empirical analysis show that the scheme can effectively evaluate the performance of financial management, so as to provide pertinent suggestions for management decision-makers.

2. Related Work

2.1 Connotation of Financial Management Performance in Colleges and Universities

The financial performance of colleges and universities can be used to measure whether colleges and universities can make sufficient contributions to the final development of colleges and universities when implementing development strategies. For colleges and universities in China, financial performance evaluation can measure whether their current financial management level can complete the evaluation process of rational utilization of college resources The financial performance evaluation of colleges and universities needs to select specific indicators to measure the financial performance evaluation of colleges and universities, and know the performance management level through comparison. The main content of university financial performance evaluation is the input and output of university finance Among them, the investment of colleges and universities mainly refers to the investment of teaching and scientific research funds, while the output of colleges and universities mainly refers to the scientific and technological output of colleges and universities, academic papers, talent training and other achievements [3].

The main goal of performance evaluation of colleges and universities is to show and evaluate the efficiency of resource use in Colleges and universities with the method of financial profit and loss comparison For our government, through this performance evaluation, we can better evaluate the utilization and effectiveness of resources in Colleges and universities, to realize the rational allocation of resources in colleges and universities according to the evaluation results; the goal of this evaluation is to make them fully understand the characteristics of their own resource use, and then optimize

the use of internal resources in Colleges and universities.

2.2 General Procedures of AHP

AHP is a decision-making analysis method combining qualitative and quantitative analysis. It uses the experience of decision makers to judge the relative importance of the standards between the realization of each measurement goal, and reasonably gives the weight of each standard of each decision-making scheme, and uses the weight to calculate the order of excellence of each scheme, which is more effectively applied to those topics that are difficult to be solved by quantitative methods., It has a very wide range of practicality. AHP decomposes the complex problem into various constituent factors, and then groups these factors according to the dominant relationship to form a hierarchical structure. Determine the relative importance of various factors in the hierarchy by comparing them. Then, the overall ranking of the relative importance of alternatives is determined based on the judgment of personnel. The whole process embodies the ideological characteristics of "entry decomposition problem judgment synthesis".

Step 1: establish a hierarchical structure and determine the target layer, criterion layer and scheme layer. The criteria layer refers to the factors that need to be taken into account when making decisions; The "objective" of "multi-objective decision-making" actually refers to the multiple utilities that we want to achieve, which generally corresponds to the criterion level;

Step 2: construct a judgment matrix, and construct a judgment matrix by comparing the factors in pairs. The judgment matrix is a matrix composed of the relative importance of all factors in this layer to a factor in the upper layer. Measuring relative importance requires the introduction of "scaling method", which generally adopts the 9-level scaling method;

Step 3: calculate eigenvalues and eigenvectors for the same level consistency test and weight calculation. First, calculate the product of each row element of a judgment matrix as

$$Z_i = X_{j=1}^{m} b_{ij}, \ \mathrm{i} = 1, 2, ..., m \tag{1}$$

Then compute the m power root of each Z_i as

$$\bar{W} = m\sqrt{Z_i} \tag{2}$$

Vector W is further normalized as

$$W_i = \frac{\bar{W}_i}{\sum_{j=1}^{m} \bar{W}_i} \tag{3}$$

Step 4: calculate the weight ranking and consistency test of the scheme layer on the target layer. It is worth noting that Step3 is the relative ranking weight of all factors at a certain level to the previous level, including the importance of the scheme layer to the criterion layer and the ranking weight of the criterion layer to the target layer; In this step, the importance of the direct scheme level to the target level is the final decision-making stage;

Step 5: calculate the composite weight of the index. This value is the total ranking ordinal number of each index in the whole target. The index weight obtained is a key link in the financial management of colleges and universities, which is used as an

important basis to guide them to make corresponding decisions.

2.3 K-means Clustering Algorithm

The K-means clustering algorithm first randomly selects K objects as the initial cluster centers, then calculates the distance between each object and each seed cluster center, and assigns each object to the nearest cluster center. The cluster center and the objects assigned to it represent a cluster. Once all objects are assigned, the cluster center of each cluster will be recalculated based on the existing objects in the cluster. Repeat this process until the clustering center no longer changes and the sum of squares of errors is locally minimized.

The basic steps of K-means clustering include: collecting data, cleaning data, data transformation, data dimensionality reduction, data transformation, determining the most significant k, clustering, and interpreting the results. Among them, the following steps are crucial:

- Data conversion: Standardize and unify dimensions to meet the needs of distance calculation while improving calculation speed
- Data dimensionality reduction: Principal component analysis (quickly determining the number of factors) and factor analysis (using factor rotation to improve results) solve the problem of curse of dimensionality, while optimizing the dataset, reducing computational complexity, and better achieving local convergence;
- Data conversion: Confirm skewness and kurtosis, and perform normal distribution transformation to avoid the problem of extreme and unbalanced clustering results;
- Determine the optimal k: Determine the optimal K through the sum of contour coefficients and dispersion squares
- Explanation of clustering results: Reflect the clustering labels on factor scores and raw data, confirm the characteristics of each group, and when there are fewer variables in the number of factors or raw data, use the tree graph of the decision tree to view the specific differences of each group

3. Performance Evaluation Method of University Financial Management Based on Weighting K-means

3.1 Financial Management Performance Evaluation Index System

The construction of financial management performance evaluation index system needs to follow scientific methods and measure fairly according to objective facts. Therefore, a series of basic principles need to be followed in the construction of index system. First, the construction of the index system needs to comply with the principle of scientificity. The scientific principle requires that the objectivity and scientificity should be maintained at all times in the process of selecting indicators, and the indicators should be selected in a scientific way to avoid the interference of subjective consciousness as far as possible, so that the indicators can be independent and complementary to each other. Second, the construction of the index system needs to comply with the principle of cost-effectiveness. Financial management performance evaluation takes input-output as the basic measurement element. In the selection of

indicators, it is necessary to select indicators that can maximize the input cost and output benefit of higher vocational colleges. The appropriate selection of indicators can better measure the input-output ratio of higher vocational colleges, and help higher vocational colleges to reasonably plan funds. Third, the construction of the index system needs to comply with the principle of comprehensiveness. Due to the wide range of financial management, if you want to evaluate the performance of financial management, the indicators need to cover the financial situation of the whole higher vocational colleges as much as possible, and comprehensively measure the financial management performance of Higher Vocational Colleges on the basis of distinguishing primary and secondary [6,7].

Based on the principles of relevance and operability, this paper designs the university financial management performance evaluation index system, which mainly includes three levels: target level, standard level and index level, as shown in table 1.

Table 1. University financial management performance evaluation index

Index classification	Weight percent	index
Profitability B1	15.6%	Per capita expenditure of Teachers C1 School financing level C2
Efficiency B2	27.1%	Student income from public institutions C3 Annual revenue expense ratio C4
Internal control B3	10.8%	Asset liability ratio C5 Current ratio C6
Culturability B4	22.4%	Graduate employment rate C7 Student loan rate C8

3.2 Comprehensive Weighting K-means Algorithm Improved By AHP

The traditional K-means clustering algorithm has problems such as the need to pre-set the K-value, and the clustering results are affected by the initial center point. In contrast, the hierarchical clustering algorithm provides a good solution for calculating K values. The logic of the hierarchical clustering algorithm is to define the initial observations as a class, and each clustering will aggregate the closest observations or classes into a new class. The hierarchical clustering algorithm also has certain drawbacks. In addition to low computational efficiency, based on the algorithm's logic, once a certain type of data is divided and aggregated into another type, that type of data will no longer participate in subsequent clustering operations, and the clustering distance reaches local optimal rather than global optimal, thereby affecting the overall clustering effect. The combination of the two clustering methods can to some extent compensate for their respective limitations [8].

In the actual implementation of AHP method, the size of the selected expert group and the differences in the academic background of the members of the expert group make the evaluation data subjective to a certain extent. Therefore, it has greater advantages than the objective weighting method in determining the weight according to the intention of the decision-maker, but the objectivity is relatively poor and needs to be continuously improved.

To evaluate the user's credit rating more accurately, the performance rating values calculated by the AHP method and the performance rating values calculated by the k-means method are weighted and averaged. This paper combines the advantages of the two algorithms, and establishes the optimization model of combined weights by

combining the subjective and objective weight relations. The specific method is described as follows:

Step 1: Collect Datasets: Collect datasets that require clustering analysis. Use the AHP method to preliminarily assign weights to each attribute in the dataset, and determine the degree of influence of each attribute on the clustering results;

Step 2: Normalize data: Normalize the dataset according to a formula to ensure that all attributes have the same importance.

Step 3: Initialize Cluster Centers: Randomly select K initial cluster centers, where K is the pre-set number of cluster clusters.

Step 4: Calculate the distance between the sample and the cluster center: Use Euclidean distance or other distance measurement methods to calculate the distance between each sample and each cluster center.

Step 5: Sample allocation: Assign each sample to the cluster to which the cluster center closest to it belongs.

Step 6: Update Cluster Center: Calculate the average value of samples in each cluster and use it as the new cluster center.

Step 7: Let the comprehensive weight vector be $\mathrm{w} = \alpha w' + \beta w''$, where α and β are undetermined coefficient of subjective and objective combination for weighting, $\alpha + \beta = 1$. Difference coefficient method is adopted as $\alpha = \frac{nT'}{n-1}$, where T is the difference coefficient of each component of w' and $T' = \frac{2}{n}(1p_1 + 2p_2 + ... + np_n) - \frac{1+\mathrm{n}}{n}$, where p1,pn are the rearrangement of subjective weight vector w' from small to large, n is the number of attributes. Then $\beta = 1 - \alpha$ and it is substituted to $\mathrm{w} = \alpha w' + \beta w''$ to acquire the comprehensive weight vector of all attributes.

Step 8: Output clustering results: Assign each sample to the final determined cluster to obtain the final clustering result.

3.3 Empirical Analysis

(1) Case background

There are 15920 ordinary undergraduates in case university, and the level of funding per student in local colleges and universities has not increased year by year. The universities implement the financial model of "unified leadership, hierarchical management and centralized accounting". Under the implementation of the new budget management law, the implementation of projects in Colleges and universities can make the budget content clear and the revenue and expenditure issues clear. In addition, the whole process of budget management in Colleges and universities can be refined from preparation to implementation, so that its budget work can be guaranteed, to play the role of financial management in promoting the development of colleges and universities.

The balance sheet, income and expenditure statement, final financial statements and internal financial data of the college in recent three years are shown in table 2 and 3. It can be seen that the expenditure of the college is infrastructure construction, equipment procurement, etc; In addition to local financial allocations, the income mainly comes from tuition fees and social donations; Other major financial funds also include

infrastructure loans, teaching and scientific research income, school run enterprises revenue and expenditure, etc.

Table 2. Financial revenue structure of the school in recent three years

Item	Year		
	2019	2020	2021
Local appropriation	21.89%	27.19%	27.15%
Tuition	29.56%	45.31%	53.69%
Social donation	35.41%	10.58%	8.35%
Financial aid	1.2%	3.414%	8.55%
Others	16.4%	16.27%	11.28%

Table 3. Financial expenditure structure of the school in recent three years

Item	Year		
	2019	2020	2021
Infrastructure construction	35.6%	21.54%	21.99%
Device purchasing	4.7%	7.9%	6.01%
Teacher construction	0.88%	1.4%	1.87%
Teaching funds	1.12%	1.1%	1.35%
Library construction	1.34%	0.6%	0.33%
Others	6.8%	7.8%	8.42%

(2) Construct judgment matrix

According to the hierarchical model constructed in table 1, a questionnaire was designed to investigate and sort out the research scholars in the direction of financial performance evaluation and the financial departments of colleges and universities. The questionnaire is designed according to the 1-9 scale method. Finally, the questionnaire is withdrawn and the expert scoring is obtained. The judgment matrix is determined as follows:

$$\begin{pmatrix} 1 & \frac{1}{3} & \frac{1}{5} & 3 \\ 3 & 1 & \frac{1}{3} & 3 \\ 5 & 3 & 1 & 5 \\ \frac{1}{3} & \frac{1}{3} & \frac{1}{5} & 1 \end{pmatrix}$$

(3) Normalization processing

Since $\sum a_n = 1+3+2 = 6$, we have $\overline{a}_{11} = 1/6 = 0.167$. Similarly, the normalized matrix is acquired by a_n, that is

$$A = \begin{pmatrix} 0.167 & 0.182 & 0.143 \\ 0.500 & 0.545 & 0.571 \\ 0.333 & 0.273 & 0.286 \end{pmatrix}$$

(4) Consistency test

The computation results are acquired by MATLAB. CI is the consistency index and CR is random consistency index. Then matrix A: $W = \begin{pmatrix} 0.1396 \\ 0.2455 \\ 0.0789 \\ 0.5496 \end{pmatrix} CR = 0.0735$,

$B_1 : W = \begin{pmatrix} 0.75 \\ 0.25 \end{pmatrix}$. Therefore, the rest matrix can be obtained and they are completely consistent.

(5) Combination weight calculation

Process the relevant data of financial management performance evaluation using the K-means algorithm with comprehensive weighting. Randomly select 4 user data as the center of each initial category. List the dataset containing financial management performance evaluation indicators, including revenue growth rate, profit margin, asset return rate, and other indicators. The specific clustering class center and the information contained in each class will depend on the specific situation of the dataset. The clustering center of each class represents the average value of the class on various indicators, and the information contained in each class is the sample data within that class. The final weight values obtained by calculating the management performance indicators in the sample are shown in Table 4. After the above calculation, the weight calculation results of various indicators are shown in figure 1.

Table 4. Final indicator weighting level

Indicator	C1	C2	C3	C4	C5	C6	C7	C8
Weight	0.35	0.32	0.88	0.71	0.75	0.35	0.19	0.18
LEVEL	C	C	A	B	B	C	D	D

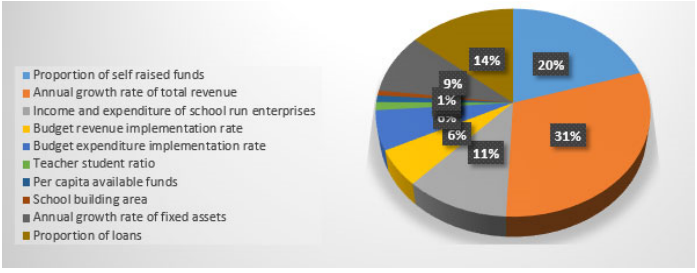

Figure 1. Weight distribution of financial performance indicators in universities

This paper discusses the scientific evaluation methods of financial performance management in colleges and universities. Through the actual data of the financial income and expenditure of a university in recent three years, we summarize several factors that affect performance management, and establish the corresponding index system. Then in the evaluation process, for some problems existing in the traditional AHP model, the CRTIC model is combined with it to calculate the weight, so as to get a more accurate weight allocation strategy. Finally, the final influential indicators are obtained from the comprehensive evaluation value table to provide managers with more objective decision-making reference.

4. Conclusions

This paper discusses the scientific evaluation methods of financial performance management in colleges and universities. Through the actual data of the financial income and expenditure of a university in recent three years, we summarize several factors that affect performance management, and establish the corresponding index system. Then in the evaluation process, for some problems existing in the traditional AHP model, the k-means model is combined with it to calculate the weight, to get a more accurate weight allocation strategy. Finally, the final influential indicators are obtained from the comprehensive evaluation value table to provide managers with more objective decision-making reference.

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